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(71) We, BELOIT CORPORATION of Beloit, Wisconsin 53511, County of Rock and State of Wisconsin, United States of America, a corporation organised and existing under the laws of the State of Wisconsin, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to fibrous web formation and more particularly to an improved twin wire apparatus for producing quality paper webs from dilute aqueous suspensions of paper stock.

In relatively recent years twin-wire paper-forming apparatus have been developed, providing significant advances in the paper making art over the conventional Fourdrinier-type paper forming machines. Although certain of the known twin wire forming machines are operational, a number of defects still exist. For example, some twin-wire machines drain paper stock through substantially only one wire; others occupy too much space and/or rely too heavily on artificially created dewatering forces; others have excessive deviations in the path of travel within the forming zone causing excessive wear of the travelling wires and/or marking of the newly forming web; others fail sufficiently to dewater the stock and/or require complex dewatering-elements thereby adding to the overall cost of paper production: yet others provide excessive unsupported wire-run-reaches allowing fluttering and the like to take place thus detracting from quality paper formation, and so on.

Essentially, the present invention provides an improved twin-wire paper-forming arrangement overcoming at least a substantial number of the defects in known twin-wire machines whereby economical and high quality paper is produced.

The invention provides an essentially vertically-oriented (up or down) paper-forming machine having a forming-zone including a pair of looped forming-wires arranged to converge and provide an entrance nip for the reception of stock, means for supporting and driving the wires in their loops, a stationary guide means comprising a plurality of curved stationary guide surfaces positioned downstream of the entrance nip and arranged to define an elongated curved path of travel directing one of the wires against the other wire so as to dewater the stock sandwiched between the wires, a large diameter dewatering-roll positioned immediately downstream of the last of the plurality of stationary guide surfaces arranged so that the wires travel around a part of the peripheral surface of the roll, with the roll and the stationary guide means arranged on the same side of the wires so that one of the wires is free of restraint means opposite the stationary guide means and the roll. The wires are driven at a speed so that a substantial amount of water in the stock is forced centrifugally through the wire free of restraining means.

In certain embodiments, the plurality of curved stationary guide surfaces include a water-impermeable curved surface having a given relatively large radius of curvature followed by a stationary suction means having a peripheral surface with a radius of curvature about equal to or less than the given radius of curvature and generally larger than the radius of curvature of the roll. In other embodiments, the plurality of stationary guide surfaces include a water-permeable curved surface, such as a plurality of longitudinally-spaced transverse wire-contacting thin edges arranged so that the longitudinal contour of such edges defines a curve of a given relatively large radius of curvature followed by one or more stationary dewatering elements having peripheral surfaces with a radius of curvature not more than the given radius of curvature and generally greater than the radius of curvature of the roll. Housing means are provided around one or more of the plurality of stationary guide surfaces for maintaining a sub-atmospheric pressure in working relationship with such guide surfaces in certain

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of the embodiments. Water-skimming means and anti-flutter means are provided in running contact with the wire free of restraining means for removal of water carried along the back side of such wire and to prevent any fluttering of such wire throughout the forming zone.

The present invention provides apparatus for forming a fibrous web and including: first and second continuous forming-wires which are arranged to converge and provide an entrance nip for the reception of stock, a stationary guide means, means for supporting and driving the wires into close relationship to form the entrance, the forming wires being arranged to travel over the stationary guide means downstream of the entrance nip while having stock between them, a rotary cylinder, the wires travelling around a part of the periphery of the rotary cylinder following the stationary guide means, which latter and the rotary cylinder are on the same side of the wires, and engage the second wire, and the first wire being free of restraint means opposite the stationary guide means and the rotary cylinder and the wires being arranged to travel at a speed such that the stock is dewatered centrifugally through the first wire, the apparatus being characterised in that the stationary guide means consists of a plurality of stationary surfaces arranged to define an elongated curved wire path of travel directing the first wire against the second wire for removal of water from the sandwiched stock.

The accompanying drawings show, by way of example, two constructional forms of the invention. In the drawings:—

Fig. 1 is an essentially diagrammatic elevational view, with some parts shown in phantom, illustrating a preferred embodiment of the invention; and

Fig. 2 is a partial diagrammatical elevational view illustrating a portion of another embodiment of the invention.

A vertically-oriented paper machine 10 is illustrated at Fig. 1 and is operable either upwardly i.e., as shown or inverted. A headbox means 11 is provided with a source (not shown) of paper stock and directs the stock outwardly therefrom as a jet-stream of paper stock. The outlet opening of the headbox means 11 is oriented so that a centre axis *a* thereof is substantially tangential to the peripheral surfaces of breast rolls 12 and 13 defining the entrance nip N-1.

The stock entrance nip N-1 is defined by the distance between the breast rolls 12 and 13, which are mounted for rotation by conventional means which may be provided with adjustment means (not shown) for varying the space between the rolls. The breast rolls 12 and 13 are of either open or solid construction and, in a preferred arrangement, the roll 12 is in open breast roll and the roll 13 is a solid breast roll, as shown.

A first loop-forming wire F1 wraps the breast roll 12 and travels therewith through the entrance nip N-1 and a second loop-forming wire F2 wraps the breast roll 13 and travels through the entrance nip N-1 and converges with the wire F1. The wires F1, F2 are provided with means for supporting and driving them within their loops, such as guide rolls 19 and 19′, some of which are provided with tensioning means T and T′ respectively, and drive means M1 and M2. The drive means M1 and M2 are synchronized with each other and with the speed of the jet stream of stock being provided by the headbox means 11 and drive the wires F1, F2 at a speed sufficient to centrifugally dewater the stock between the wires.

The forming-wires F1 and F2 are composed of bronze, steel, copper, plastics or fabric strands woven in an open mesh to define suitably sized endless loops. The forming-wires may also be formed of a plurality of different materials combined to yield certain specific characteristics, i.e., wear, stretch, weight, strength, surface pattern, and so on.

The jet stream of stock impinges on the surfaces of the forming-wires F1 and F2 as they travel over the rolls 12 and 13 and in accordance with the previously indicated preferred orientation of the headbox means 11, the jet stream of stock generally contacts one of the wires, i.e. F2 before the other of the wires. Dewatering begins at the immediate off-running side of the rolls 12 and 13 by essentially a drainage phenomena without any pumping or other disruptive action by the rolls. During these early stages of web formation, pumping is detrimental to proper fibre distribution and creates undesirable marking on the forming-web and is therefore to be avoided.

It will be noted that the general orientation of the headbox means 11, the entrance nip N-1 and the associated wire runs is such that the natural jet-stream projectory is maintained throughout this area. In this manner natural drainage phenomena is materially aided and there is a relatively easy pressure on the paper stock at this area. This easy pressure merely contains the moving fibres in the confined zone between the forming wires without exerting any actual pressure thereon and allows the substantial portion of water to be drained at this area of the forming machine without the application of any disruptive pressures, which may cause shearing, uneven fibre distribution or like defects disturbing the formation of high quality paper. Initial dewatering occurs along the areas A1 and A2 in substantially opposing direction from the entrance nip N-1 as shown, without pumping and along both surfaces of the newly forming web, thereby allowing proper distributions of the fibres within such

web without adversely effecting the characteristics of the web.

The forming wires F1 and F2 are arranged so as to continue travelling together and to converge into general parallelism downstream from the entrance nip N-1. A plurality of stationary guide surfaces 14 and 16 are positioned downstream of the entrance nip N-1 and arranged to define an elongated curved path of wire travel directing one of the wires against the other wire so as to dewater the stock sandwiched between the wires. The term "general parallelism" as used herein will be understood to include the dynamic or changing relationship of the wires toward one another as caused by the slight spacing or separation of such wires by the sandwiched web therebetween and permits the slight movement of the respective wires toward one another as water is removed from the forming web. It will be appreciated that as the paper stock is dewatered, wire tension in each of the wires urges the wires closer toward one another due to the smaller quantity of matter between such wires. Thus, proper tensioning of the respective wire runs materially aids in the dewatering of the newly formed paper web.

In the embodiment shown in Fig. 1, the first of the plurality of curved stationary guide surfaces is indicated as an element 15 and generally comprises a water-permeable curved surface formed of a plurality of longitudinally-spaced transverse wire-contacting thin edges 15*a* arranged so that the longitudinal contour of such edges 15*a* defines a curvature having a given relatively large radius of curvature. The relatively thin edges 15*a* are formed, at least along their wire contacting portions, of a suitable anti-friction and wear resistant material, such as ceramics, various plastics, and so on. The relatively large radius of curvature of the guide surface 15 prevents substantial normal or perpendicular pressure loading of one of the wires against the other wire thereby preventing undue frictional engagement between the travelling wires and the first stationary guide element 15 and further allows water to be gradually removed from the sandwiched stock into areas A3 and A'3 whereby spewing and like undesirable disruptance phenomena are avoided. A suitable housing means 15*b* is provided in working relation with the guide element 15 for maintaining sub-atmospheric pressure around it so as to aid in water removal through the longitudinal spacing between the wire-contacting edges 15*a*. A stationary dewatering means 16 is positioned downstream of the stationary guide surface 14 (which in certain embodiments comprise a plurality of individual stationary guide surface 15*a* and on the same side of the wires as the guide surface 14. The stationary dewatering means 16 comprises, in certain embodiments, a suction box 16*a* having conventional means of maintaining sub-atmospheric pressure therein for drawing water and the like inwardly from its peripheral surface 16*b*. The surface 16*b* is preferably provided with a slight degree of curvature so as to have a radius of curvature about equal to or less than the radius of curvature of the guide element 16; however, in certain embodiments the peripheral surface 16*b* may be an essentially flat surface in working contact with the wire runs.

In other embodiments, the first of the plurality of curved stationary guide surfaces comprises a substantially water-impermeable, stationary smooth generally-curved surface 15*a*, as shown at Fig. 2. The guide surface 14*a* is provided with a relatively large radius of curvature so as to prevent undue engagement with the travelling wire runs and minimize the pressure being exerted by such wires on the sandwiched stock. The surface 14*a* is provided with a curved leading edge 14*b* so as to further reduce the friction and wear on the travelling wire runs and is provided with a trailing edge 14*c* diverging abruptly away from the travelling wire runs so as to avoid pumping.

Referring back to Fig. 1, a water-skimming means 17 is provided in running contact with the wire F1 at a location substantially opposite the guide element 15 in the vicinity of its off-running edge. Water-skimming means 17 is positioned in an extremely close working relation with the travelling wires-run to skim-off any water that may be adhering to the back side of the wire F1. The water skimming means 17 thus engages and removes water that is adhering to the back side of the wire run F1 but does not cause any wire-directional changes and there is little, if any, frictional engagement between the travelling wires and the water skimming means 17. The water-skimming means 17 removes the water from the wire runs and directs it into appropriate save all devices S*a* for removal through appropriate conduits C passing the express water to a desired location for re-use or the like. The water-skimming meaens 17 in no way interferes or restrains the water being forced from the wires and the wire F1 is free of any restraint means in the area opposite the plurality of stationary guide surfaces. While only one such water-skimming means 17 is illustrated, additional ones may be provided as desired.

The two travelling wires are then guided over a large diameter dewatering roll 20 positioned downstream of the stationary dewatering-means 16, and it will be appreciated that more than one such dewatering-means 16 is provided in certain embodiments of the invention to minimize unsupported wire run reaches between the various guide elements. The dewatering-roll 20 is preferably a large diameter suction roll having one or more sub-atmospheric compartments, such as 19, 21 and 22, and is arranged so that the travelling

wires F1, F2 travel around a part of the peripheral surface of the roll 20, with the plurality of stationary guide surfaces 14, 16 and the roll 20 being on the same side of the wire runs, and in the illustrated embodiment on the same side of the wire F2 so that the other wire i.e. the wire F1 is free of restraint means opposite the said various guide elements.

Anti-fluttering means 18 are positioned in working relationship to the wire free from restraining means, i.e. the wire F1, at various areas throughout the forming zone to prevent fluttering and/or other deviations in the path of travel of the travelling wires. The anti-fluttering means 18 does not restrain water movement through the opposed wire runs and is not in wire-directional changing engagement with either of the wires. An auxiliary anti-fluttering means 18*a* provides pressurized air or the like to further maintain the wires along the desired path of travel and to encourage the newly formed paper web W to adhere to the wire F2 and depart from the wire F1.

In the embodiments of the invention wherein sub-atmospheric pressure is utilised at the guide surfaces 14 and 16 as well as the roll 20, it is preferable that the sub-atmospheric pressure at the guide surface 14 should be less than that at the guide surface 16 which in turn is less than at the sub-atmospheric compartments of the roll 20, each of which is provided with increased amounts of sub-atmospheric pressure, i.e., the compartment 19 is provided with less vacuum than the compartment 21, etc. This gradual increase of sub-atmospheric pressure provides controlled dewatering of the forming web without requiring excessive energy or subjecting the newly forming web to pressures which may damage it.

During the wire travel around a portion of the periphery of the roll 20, the wire F1 separates from the wire F2 and is guided around the means 19 substantially as shown, while the wire F2 carries the newly formed web W away from the forming zone and to a pickup nip PN-1. A laterally-continuous stationary dewatering means 17*a*, substantially similar to the water skimming means 17 is provided on the immediate off-running side of the roll 20 to remove any water or the like adhering to the back side of the wire F2. Additionally, doctor means 12*a*, 13*a* are provided in working relation with the rolls 12 and 13 respectively, as well as with the various guide means 19, 19′ as described so as to cleanse the peripheral surface of such rolls. Support means S, shown in phantom, are conventionally provided supporting the various elements of the forming machine 10.

The wire F2 carries the newly formed web W along its outer surface downwardly and into contact with a pickup roll 24 having a suction gland 24*a*. A looped pickup felt PF is guided through a felt only press nip FN-1 defined by press rolls 25, 26 and guided by suitable guide rolls in a loop (not shown) and around pickup roll 24 so as to come into contact with the web W. The web W adheres to the pickup felt PF by virtue of the fact that the pickup felt PF has a denser surface than the wire F2 and because of the difference in pressure created by the suction gland 24*a*. The pickup felt PF carries the web W along its undesirable surface to a first web press nip WN-1 defined by rolls 26, 27 or to other suitable locations for further processing as desired. The press rolls 25, 26 and 27 may be any conventional press rolls, such as plain rolls, blind-drilled rolls, suction rolls, grooved rolls, and so on.

WHAT WE CLAIM IS:—

1. Apparatus for forming a fibrous web and including: first and second continuous forming-wires which are arranged to converge and provide an entrance nip for the reception of stock, a stationary guide means, means for supporting and driving the wires into close relationship to form the entrance, the forming wires being arranged to travel over the stationary guide means downstream of the entrance nip while having stock between them, a rotary cylinder, the wires travelling around a part of the periphery of the rotary cylinder following the stationary guide means, which latter and the rotary cylinder are on the same side of the wires, and engage the second wire, and the first wire being free of restraint means opposite the stationary guide meeans and the rotary cylinder and the wires being arranged to travel at a speed such that the stock is dewatered centrifugally through the first wire, the apparatus being characterised in that the stationary guide means consists of a plurality of stationary surfaces arranged to define an elongated curved wire path of travel directing the first wire against the second wire for removal of water from the sandwiched stock.

2. Apparatus as claimed in claim 1, wherein the plurality of stationary surfaces comprises a substantially water-impermeable curved surface followed by at least one stationary dewatering surface.

3. Apparatus as claimed in claim 1, wherein the plurality of stationary curved surfaces comprises a substantially water-permeable curved surface followed by at least one stationary dewatering surface.

4. Apparatus as claimed in claim 1, 2 or 3, wherein a first of the plurality of stationary surfaces is provided with a relatively large radius of curvature and a second of the plurality of stationary surfaces is provided with a radius of curvature less than the large radius of curvature but larger than the radius of curvature of said rotary cylinder.

5. Apparatus as claimed in any of the preceding claims, wherein the stationary guide

means is a curved stationary surface followed by a stationary dewatering surface and the rotary cylinder is a relatively large diameter suction roll having a given radius, the curved stationary surface having a radius greater than the said given radius and the stationary dewatering surface having a radius greater than the given radius but less than the radius of the curved stationary surface.

6. Apparatus for forming a fibrous web, substantially as described with reference to the accompanying drawings.

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1378055 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*